



Hydrogen Membrane Processing, Analysis, and Characterization

Product Line: Gasification Technologies, Research and Development, Gas Separation

Background/Description

Inorganic membranes provide superior thermal and chemical stability when compared to commercially available organic membranes. Inorganic membranes can be classified as metallic, ceramic, or ceramic-metal composite, called a cermet. Potential application of ceramic membranes are extensive and include hydrogen and oxygen production, partial oxidation or oxidative coupling of natural gas, chemical synthesis, and energy production. Ceramic membranes can be used to improve efficiency and performance of a wide range of Vision 21 fossil energy systems. Gas separation and purification are among the most important applications of such devices.

Dense ceramic membranes are very promising candidates for commercial hydrogen production. Hydrogen is incorporated as defects in oxides and is easily protonated. Protons exhibit relatively high mobilities in oxides and in high concentrations give rise to protonic conductivities. Proton conductors can be used in hydrogen pumps, sensors, electrochemical reactors, and fuel cells. The membrane consists of solid state electrochemical materials with mixed, protonic and electronic conductivity.

Proton conducting solid electrolytes operating at lower temperatures (polymers, hydroxides, hydrates, acid salts, and hydrogen insertion compounds) contain protons as a major constituent. The protons are easily lost during use, with subsequent failure of the electrolyte. Proton conducting oxides offer structural and chemical stability during use at high temperatures as protons are not critical for the composition or structure of the oxides.

Hydrogen separation membranes using Pd or a micro porous membrane are under development. There is a belief that there is not enough Pd in this planet to support commercialization of Pd based membranes. The micro porous membranes cannot operate above 600°C, thereby prohibiting their use in coal gas or methane partial oxidation product streams. This creates a need to develop dense ceramic mixed proton-electron conductors.

Goal

The goal of this project is to (a) develop novel designs for compact hydrogen separation membranes, (b) model the designs to determine optimal method for synthesis of mixed protonic-electronic conductors and manufacturing feasibility, and (c) fabricate novel proton-electron conducting membranes for testing.

Benefits

The successful development of dense ceramic mixed proton-electron conductors will permit use of hydrogen separation membranes in high temperature gas streams to increase efficiency and reduce costs for hydrogen production.

Contact Information

Project Lead Organization

Oak Ridge National Laboratory
1 Bethel Valley Road
Oak Ridge, TN 37831
www.ornl.gov

Principal Investigator

Timothy R. Armstrong
(865) 574-7996
armstrongt@ornl.gov

Other Participants

None

Project Funding

DOE \$850,000
Non-DOE \$ 0
Total \$700,000

Period of Performance

Oct. 1999 to Sep. 2004

NETL Product Manager

Gary J. Stiegel
(412-386-4499)
626 Cochran's Mill Rd.
Pittsburgh, PA 15236
gary.stiegel@netl.doe.gov

NETL Project Manager

Arun Bose
412-386-4467
626 Cochran's Mill Rd.
Pittsburgh, PA 15236
arun.bose@netl.doe.gov

continued...

NETL Hydrogen Projects

Status as of December 2003:

- Prepared near full-density samples from both co-precipitated and combustion synthesized (standard GNP) powders.
- Initiated mechanical property measurements and a mechanical test methodology, including strength measurements as a function of temperature and stressing rate in an air environment.
- Completed an initial analysis of the layered system $\text{La}_2\text{SrTi}_3\text{O}_{10}$ and initial analyses of pyrochlore-perovskite binary systems.

Schedule

FY 2004:

- Complete initial analysis of Li_2TiO_3 system and initiate supporting mechanical and thermal testing if warranted by electrical and flux data on layered and binary systems.
- Complete the computational model for the pyrochlore system to predict phase stability of the test compositions, defect chemistries, identify proton migration pathways, and calculate activation energies for proton conduction and the factors that most influence them.
- Complete initial analysis and preparation of the La_2O_3 - SrO - Ta_2O_5 system.

Images/Diagrams

